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Invention: A METHOD AND APPARATUS FOR RECOGNIZING A RECEIVING PATH IN A CDMA SYSTEM

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SPECIFICATION

A METHOD AND APPARATUS FOR RECOGNIZING A
RECEIVING PATH IN A CDMA SYSTEM

This patent application claims priority based on a
Japanese patent application, 2000-4317, filed on January 13,

5   2000, the contents of which are incorporated herein by
reference.

BACKGROUND OF THE INVENTION

The present invention relates to a method for

10   recognizing a valid receiving path for demodulating received
signals transmitted through a plurality of transmission paths
in a CDMA (Code Division Multiple Access) wireless
telecommunication .system. More specifically, the invention is
directed to a method for recognizing a valid receiving path

15   for demodulating received signals based on a distortion of a
correlation profile expressed by, for example, a delay
profile acquired out of correlation values, and to a mobile
station which embodies the method.

Fig. 1 is a block diagram showing an example of a

20   conventional base band signal processor 10 of a CDMA mobile
station. The base band signal processor 10 includes a spread
code generator 12, a correlator 14, a memory 16, a comparator
18 and registers 20 and 22. The register 20 stores a
predetermined path recognition threshold value, and the

25   register 22 stores a predetermined noise threshold value.

The spread code generator 12 generates a plurality of
phase-shifted spread codes, each of which is comprised of a
predetermined number of spread code bits. The correlator 14
acquires a correlation value by determining correlation

30   between a set of received signals and a spread code. In a

specific receiving path through which a specific set of signals is transmitted, there may be a plurality of correlation values acquired by determining correlations of the set of received signals and a plurality of spread codes.

5   The memory 16 stores the correlation values of several receiving paths thus acquired by the correlator 14. The comparator 18 determines whether a specific set of received signals of a specific path is noise or not by comparing the correlation values for that set of received signals with the

10   noise threshold value. The comparator 18 also compares a peak correlation value out of the correlation values for that set of received signals with the path recognition threshold value. The path of which the peak correlation value is larger than the path recognition threshold value is recognized as a valid

15   receiving path for demodulation, and the location of the peak correlation value is stored as a path location for the receiving path in the memory 16.

Fig. 2 is a flowchart of a conventional path recognizing process performed by the conventional base band

20   signal processor 10. At step S10, the path recognizing process starts. At step S12, the correlation values of a set of received signals through a specific path with spread codes are acquired. At step S14, the correlation values are stored

25   into the memory 16, so that each of the correlation values are compared with the noise threshold value at steps 16. If one of the correlation values is smaller than the noise threshold value, the set of signals having that correlation value at that delay time is recognized as noise at step S20.

30   If all of the correlation values are larger than the noise threshold value, a peak correlation value out of the correlation values of the path is compared with the path recognition threshold value at step S18.

If the peak correlation value is smaller than the path recognition threshold value, the set of signals having that peak correlation value at that delay time is recognized as noise at step S20. If the peak correlation value is larger than the path recognition threshold value, the path having that peak value is recognized as a valid receiving path for demodulation, and the level and the delay time of the peak correlation value are stored into the memory 16 at step S22. At step S24 the process terminates.

However, some known negative phenomena, such as Fading or Doppler effect, generally deteriorate transmission paths so that the transmission paths may be influenced by interference signals and noises. In this case, the peak correlation value of a deteriorated path is prone to be smaller than the path recognition threshold value designed for a conventional path recognition process as described above. This results in less of the path having that peak value because the path could not be recognized as a valid receiving path for demodulating signals. Therefore, in an area of weak radiation field, it is generally impossible to recognize a valid receiving path for demodulation and to establish a reliable telecommunication link.

Further, a mobile station, which receives signals intermittently, may enter into a "sleep mode" for battery saving purpose, and the circuitry of the mobile station in the sleep mode is in standby state. In this case, if the mobile station can not recognize a valid receiving path, the mobile station mustrecover from the sleep mode and search for a valid receiving path. This results in increase of power consumption and decreases the duration of the battery.

The difficulties and limitations suggested in the

preceding are not intended to be exhaustive, but rather are among many which demonstrate that prior art CDMA wireless telecommunication systems of the type described herein will admit to worthwhile improvement.

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OBJECTS OF THE INVENTION

It is therefore a general object of the invention to provide an improved method and CDMA mobile station thereof
10   which will obviate or minimize difficulties of the type previously described.

It is a specific object of the present invention to provide a method and a system for recognizing a valid
15   receiving path which make it possible to recognize a path, having low level signals, which conventionally is treated as useless, as one of the valid receiving paths.

SUMMARY OF THE INVENTION

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To achieve the foregoing objects, the present invention provides a method for recognizing a valid receiving path for demodulating received signals out of a plurality of receiving paths in a CDMA wireless telecommunication system including
25   the steps of: receiving at least one set of signals through a transmission path, the set of signals being comprised of a predetermined number of received signals; generating at least two spread codes each of which has its own delay time, the spread codes being comprised of a predetermined number of
30   spread code bits; calculating at least two correlation values of the set of signals with the at least two spread codes; and recognizing the path as a valid receiving path for demodulating the received signals based on the at least two correlation values.

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The present invention further provides a CDMA wireless telecommunication mobile station for receiving a set of telecommunication signals through a telecommunication path from a base station including: a spread code generator for generating at least two spread codes each of which has its own delay time, the spread codes being comprised of a predetermined number of spread code bits; a correlator for calculating at least two correlation values of the set of signals with the at least two spread codes; and a path recognizing unit for recognizing the path as a valid receiving path for demodulating the received signals based on the at least two correlation values.

BRIEF DESCRIPTION OF THE DRAWINGS

Other objects and advantages of the present invention will become apparent from the following detailed description of prepared embodiments thereof taken in conjunction with the accompanying drawings, wherein:

Fig. 1 is a block diagram showing an example of a conventional base band signal processor of a CDMA mobile station.

Fig. 2 is a flowchart of a conventional path recognizing process performed by the conventional base band signal processor of Fig. 1.

Fig. 3 is a schematic block diagram showing a CDMA telecommunication system according to the present invention.

Fig. 4 is a block diagram showing an example of a structure of the mobile station.

Fig. 5 is a block diagram showing a functional structure of a base transceiver system (BTS) of the base station.

Fig. 6 is a schematic block diagram showing an

embodiment of the base band signal processor of the mobile station according to the present invention.

Figs. 7(a) and 7(b) show graphs of path waveforms of receiving paths represented by impulse responses or delay profiles.

Figs. 8(a) and 8(b) show graphs of frequency transfer functions or frequency characteristics acquired by performing Fourier Transformation on correlation profile waveforms.

Fig. 9 is a block diagram of an embodiment of the waveform distortion detector 80 of the present invention.

Fig. 10 is a graph of a delay profile showing relations among a peak correlation value p(N) and each of the correlation values of a receiving path.

Fig. 11 is a flowchart showing process steps for an embodiment of a method for recognizing a valid receiving path according to the present invention.

Fig. 12 is a flowchart showing an embodiment of a distortion determination process according to the present invention.

Fig. 13 is a graph showing a simulation result of a path evaluation performed on paths of consecutive 16 time slots.

DETAILED DESCRIPTION OF THE INVENTION

Fig. 3 is a schematic block diagram showing a CDMA telecommunication system 100 according to the present invention. The CDMA telecommunication system 100 includes a mobile station 30, a base station 50 and a base station control unit 70. The base station control unit 70 may control one or more of base stations. The base station 50 and the base station control unit 70 may be coupled by wired communication link. A wireless communication link is established between the base station 50 and the mobile

station 30.

Fig. 4 is a block diagram showing an example of a
structure of the mobile station 30. The mobile station 30
includes a transceiver 32, which transmits or receives
5   telecommunication signals, a transmission/reception amplifier
34, a controller 36, an RF signal processor 38, a base band
signal processor 40 and a terminal interface unit 42. The
transceiver 32 may be an antenna or antennae. The transceiver
32 transmits reverse-link RF signals amplified by the
10   transmission amplifier and receives high bandwidth forward-
link RF signals from the base station 50. The
transmission/reception amplifier 34 includes a transmission
amplifier (or High Power Amplifier: HPA), which amplifies RF
transmission signals, and a low noise amplifier (LNA) that
15   amplifies RF received signals. Further, the
transmission/reception amplifier 34 separates RF transmission
signals from RF received signals or vice versa. The RF signal
processor 38 performs orthogonal modulation and D/A
converting on the base band transmission signals spread by
20   the base band signal processor 40 finally resulting in RF
transmission signals. The RF signal processor 38 further
performs quasi-synchronized wave detection and A/D converting
on the received signals from the transmission/reception
amplifier 34, and sends converted signals to the base band
25   signal processor 40.

The base band signal processor 40 performs a base band
signal processing on the transmission or received signals. In
other words, the base band signal processor 40 performs on
transmission signals the processing of error correction
30   encoding, frame encoding, data modulation and spread
modulation, and then sends the processed signals to the RF
signal processor 38. The base band signal processor 40

performs on the received signals sent from the RF signal
processor 38 the processing of reverse-spreading, path
recognition, chip synchronizing, error correction decoding,
data multi-separation, diversity handover composition, etc.
5   According to the present invention, even under a poor
transmission path environment, the base band signal processor
40 is able to recognize a valid receiving path for
demodulating received signals. The controller 36 has control
functions such as sending and receiving control signals. The
10   terminal interface unit 42 facilitates the functions of voice
CODEC and Data Adapter (ADP) so that it facilitates an
interface function for a handset and an external data
terminal.

15   Fig. 5 is a block diagram showing a functional
structure of a base transceiver system (BTS) of the base
station 50. The base station 50 includes a transceiver 52,
which transmits or receives telecommunication signals, a
transmission/reception amplifier 54, an RF signal processor
20   56, a base band signal processor 58, an RF base station
controller 60 and a wired communication interface unit 62.
The transceiver 52 may also be an antenna or antennae. The
transceiver 52 transmits forward-link RF signals amplified by
the transmission amplifier, and receives reverse-link RF
25   signals transmitted from the mobile station 30. The
transmission/reception amplifier 54 includes a transmission
amplifier, which amplifies RF transmission signals, and a low
noise amplifier (LNA) that amplifies RF received signals.
Further, the transmission/reception amplifier 54 separates RF
30   transmission signals from RF received signals or vice versa.
The RF signal processor 56 performs orthogonal modulation and
D/A converting on the base band transmission signals spread
by the base band signal processor 58 finally resulting in RF
transmission signals. The RF signal processor 56 further

performs quasi-synchronized wave detection and A/D converting on the received signals from the transmission/reception amplifier 54, and sends converted signals to the base band signal processor 58.

The base band signal processor 58 performs a base band signal processing on the transmission or received signals. In other words, the base band signal processor 58 performs on transmission signals the processing of error correction encoding, frame encoding, data modulation and spread modulation, and then sends the processed signals to the RF signal processor 56. The base band signal processor 58 performs on the received signals sent from the RF signal processor 56 the processing of reverse spreading, chip synchronizing, error correction decoding, data multi-separation, maximum ratio composition of inter-sector diversity handover, etc. The controller 60 has control functions such as sending and receiving control signals to perform RF link establishment, RF link management, etc. The wired communication interface unit 62 facilitates an interface among the BTS, MCC-SIM (not shown) of the base station 50 and the base station control unit 70 (see Fig. 3).

Fig. 6 is a schematic block diagram showing an embodiment of the base band signal processor 40 of the mobile station 30 according to the present invention. According to this embodiment, the base band signal processor 40 includes a spread code generator 12, a correlator 14, a memory 16, a comparator 18, registers 20 and 22, a waveform distortion detector 80 and a path recognizing unit 82. The register 20 stores a predetermined path recognition threshold value, and the register 22 stores a predetermined noise threshold value.

The spread code generator 12 generates a plurality of phase-shifted spread codes each of which is comprised of a predetermined number of spread code bits, and provides the generated codes to the correlator 14. The correlator 14

5　includes, for example a matched filter and a sliding correlator, and acquires correlation values by determining correlations of received signals with the spread codes. The correlator 14 acquires a correlation profile (a multi-path profile), such as a delay profile, based on the correlation

10　values. The memory 16 stores the plurality of correlation values acquired by the correlator 14. The comparator 18 determines whether a set of received signal is noise or not by comparing the correlation values with the noise threshold value. The comparator 18 also compares a peak correlation

15　value of the path with the path recognition threshold value. A path of which the peak correlation value is larger than the path recognition threshold value is recognized as a candidate for a valid receiving path for demodulating received signals through the path, and the location of the peak correlation

20　value is stored as a path location for the receiving path in the memory 16.

The waveform distortion detector 80 determines whether there is a distortion on a path waveform of a particular

25　receiving path, where the path waveform is represented as a correlation profile, such as an impulse response or a delay profile. Otherwise, the waveform distortion detector 80 may detect a distortion on a path waveform based on a frequency transfer function or frequency characteristics, which can be

30　acquired by performing Fourier Transformation on the path waveform represented as a noise response or a delay profile.

It is quite frequent that the path waveform of a

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receiving path represented as a correlation profile, such as a delay profile, is distorted by the effects of the multi-path fading, interferences between signals, noises, etc. For example, since levels of received signals are generally low in the area having weak field strengths, the peak correlation value of the received signals can be smaller than the path recognition threshold value even though the receiving path through which the signals are transmitted was actually valid for demodulation. According to the present embodiment of the present invention, the waveform distortion detector 80 determines whether a path waveform of a correlation profile is distorted or not based on at least two correlation values. The path recognizing unit 82 recognizes at least one receiving path as a valid receiving path among a plurality of receiving paths through which signals are transmitted based on the comparison result of the comparator 18 and the determination result of the waveform distortion detector 80. The memory 16 stores the levels and a delay timing of the valid receiving path.

Figs. 7(a) and 7(b) show diagrams of path waveforms of receiving paths represented by impulse responses or delay profiles. Fig. 7(a) shows an example of a path waveform to which no distortion has occurred. As shown, this undistorted path waveform is sharp and symmetrically wedge-shaped and centered by the point p(N).

Fig. 7(b) shows an example of a path waveform to which a distortion has occurred. As shown, this distorted path waveform is of an unsymmetrical and relatively slowly sloped wedge compared to that shown in Fig. 7(a). This slow slope of the path waveform is due to the effect of interferences or noises. The waveform distortion detector 80 detects the existence of the distortion by, for example, calculating

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slopes among correlation points.

Figs. 8(a) and 8(b) show graphs of frequency transfer
functions or frequency characteristics acquired by performing
Fourier Transformation on correlation profile waveforms, such
5   as delay profile waveforms. Fig. 8(a) shows a frequency
characteristic of an undistorted path waveform. As shown, in
case distortion has not occurred, the frequency spectrum has
a shape of plane table.

10   Fig. 8(b) shows a frequency characteristic of a
distorted path waveform. Compared to Fig. 8(a), this
frequency characteristic has a very steep valley. This valley
is also due to the effect of interferences or noises. The
waveform distortion detector 80 may also detect the existence
15   of distortion on the correlation profile waveform by, for
example, calculating slopes between sample points of the
frequency characteristic.

Fig. 9 is a block diagram of an embodiment of the
waveform distortion detector 80 of the present invention. The
20   waveform distortion detector 80 includes registers 84, 86 and
88, selectors 90, 92 and 94 and a comparator 96. The waveform
distortion detector 80 of the present embodiment determines
whether there is any distortion on a path waveform of a
correlation profile by evaluating slopes of the waveform.

25   Again referring to Fig. 7, a correlation value at a
specific delay time is expressed as p(k) in a correlation
profile. At two points a and b, where b>a, a slope between
the two points a and b is given by;
(slope between points a and b) = [p(b) - p(a)]/(b-a)
30   ...(1)

Here, let β be the ratio of p(b) to p(a). That is,

p(b) = p(a) × β ...(2)

, where p(b) > p(a).

By using equations (1) and (2), we can get

5   (b-a) × (slope between points a and b) = (β-1) × p(a)
...(3)

More detailed description of the distortion detecting operation of the waveform distortion detector 80 of the present invention is given hereinafter using the above
10   equations.

As mentioned before, according to the present invention, in order to recognize a receiving path as a valid path for demodulating received signals, the shape of the path waveform represented as a correlation profile, such as impulse
15   response or delay profile, is made, and if the shape of the path waveform is not as sharp as that of an undistorted path waveform, it is determined that a distortion is present. As for a test for determining the sharpness of a waveform, a predetermined comparison threshold value is used for being
20   compared with a ratio of a sample point to another. In other words, if a waveform is sharp, the relation between the comparison threshold value and the ratio β of a sample point p(b) to another point p(a) is;

β >= (comparison threshold value)
25   ...(4)

The comparison threshold value may have different values depending on sample points.

By using equations (2) and (4), we can get

p(b) >= p(a) × (comparison threshold value)
...(5)

According to the present embodiment, if the equation
(5) is true for any of two sample points of a receiving path,
the receiving path is recognized as a valid receiving path
for demodulation and later used, for example, for RAKE
receiving operation.

Again referring to Fig. 9, the register 84 stores a
first comparison threshold value $\alpha 1$, the register 86 stores
a second comparison threshold value $\alpha 2$, and the register 88
stores a third comparison threshold value $\alpha 3$. The first
comparison threshold value $\alpha 1$ is compared to each of the
ratios of p(N) to p(N+1) and p(N-1). The second comparison
threshold value $\alpha 2$ is compared to each of the ratios of p(N)
to p(N+2) and p(N-2), and the third comparison threshold
value $\alpha 3$ is compared to each of the ratios of p(N) to p(N+3)
and p(N-3). Among the comparison threshold values, it is
preferable to have the relation of $\alpha 1 < \alpha 2 < \alpha 3$. According to
the present embodiment, a distortion on a path waveform is
detected by using the largest one from the set consisting of
p(N+m) and p(N-m). The slowest slope from the peak p(N) is
acquired by using the largest one from the set consisting of
p(N+m) and p(N-m). Then, a distortion on the path waveform is
detected by using the equation (5).

The first comparison threshold value $\alpha 1$ is multiplied
to p(N+1) and p(N-1). The selector 90 selects the largest one
from the products of $\alpha 1$ and p(N+1) and $\alpha 1$ and p(N-1), and
then provides it to the comparator 96. The comparator 96
compares p(N) with the selected product of $\alpha 1$ and p(N+1) or

α1 and p(N-1) by the selector 90.

Similarly, the second comparison threshold value α2 is multiplied to p(N+2) and p(N-2). The selector 92 selects the largest one from the products of α2 and p(N+2) and α2 and p(N-2), and then provides it to the comparator 96. The comparator 96 compares p(N) with the selected product of α2 and p(N+2) or α2 and p(N-2) by the selector 92. Further, the third comparison threshold value α3 is multiplied to p(N+3) and p(N-3). The selector 94 selects the largest one from the products of α3 and p(N+3) and α3 and p(N-3), and then provides it to the comparator 96. The comparator 96 compares p(N) with the selected product of α3 and p(N+3) or α3 and p(N-3) by the selector 94.

The comparator 96 compares p(N) with each of the products provided by the selectors 90, 92 and 94. If p(N) is equal to or larger than at least one of the products provided by the selectors 90, 92 and 94, the waveform distortion detector 80 determines that there is no distortion in the path waveform of this receiving path. Inequalities used for determining a distortion on the path waveform are as follows;

$$p(N) >= MAX[p(N+1), p(N-1)] \times \alpha1 \qquad \ldots(6)$$
$$p(N) >= MAX[p(N+2), p(N-2)] \times \alpha2 \qquad \ldots(7)$$
$$p(N) >= MAX[p(N+3), p(N-3)] \times \alpha3 \qquad \ldots(8)$$

Here, MAX[x, y] is a function having a value of the largest one from the values of x and y. In this case, the largest one from the values of p(N+m) and p(N-m) is used for detecting a distortion in a path waveform, and it is determined whether the distortion has occurred on the slow slope side of the correlation profile.

According to the present embodiment, if at least one of the inequalities (6), (7) and (8) is satisfied, it is determined that no distortion has occurred to the receiving path having a peak correlation value of p(N). If, however,

5   any one of the inequalities (6), (7) or (8) is not satisfied, it is determined that a distortion has occurred to the path waveform of the receiving path. In this example, seven sample points represent one path. If more sample points are used to represent a path, the number of inequalities used for

10   determining the existence of a distortion may be increased, and if less sample points are used, the number of necessary inequalities may be decreased. According to another embodiment, it can be made either that a distortion is detected only when all of the inequalities are satisfied or

15   that no distortion is detected when a specific one of the inequalities is satisfied. Further, according to the present embodiment, the distortion detection is performed by using the smallest one from the ratios of peak point p(N) to p(N+m) or p(N-m), but, according to another embodiment, the largest

20   ratio may be used for distortion detection. In this case, it is determined whether a distortion of the path waveform has occurred on the steep slope side of the correlation profile.

Fig. 10 is a diagram of a delay profile showing relations among a peak correlation value p(N) and each of the

25   correlation values of a receiving path. In this example, it is shown that p(N+1)>p(N-1), p(N-2)>p(N+2) and p(N-3)>p(N+3). Therefore, based on the inequalities (6), (7) and (8), if at least one of the following inequalities

$$p(N) >= p(N+1) \times \alpha 1$$
30   $$p(N) >= p(N-2) \times \alpha 2$$
$$p(N) >= p(N-3) \times \alpha 3$$

is satisfied, this path is recognized as a valid receiving path for demodulation. According to the present embodiment, p(N) is not necessarily larger than the path recognition threshold value. The fact that at least one of

5 the above inequalities is satisfied is enough to the recognition of a valid receiving path. According to another embodiment, if there are many receiving paths having respective peak correlation values larger than the path recognition threshold value, it is possible to select a most

10 appropriate path for demodulating received signals from the paths of enough peak correlation values by detecting distortions on path waveforms of correlation profiles of those paths.

15 While the present embodiment is described based on the ratios of the peak correlation value p(N) to other correlation values, as referred by the above equation (3), the ratios of p(N) to other correlation values may be converted into slope values from the peak point p(N) to other

20 sample points in the correlation profile waveform. Therefore, according to another embodiment, based on the differences of correlation values, it is possible to recognize a valid receiving path for demodulation by detecting a distortion on a path waveform of a correlation profile.

25 While, according to the present embodiment, the distortion on a path waveform is detected by using the ratios of the peak value p(N) to the correlation values other than the peak value, it is also possible to detect a distortion on a path waveform by using ratios among correlation values

30 other than the peak correlation value. For example, the ratios between neighboring correlation values or the ratios between every second or third correlation values may be used for detecting a distortion on a path waveform.

In a case where the ratios between neighboring correlation values are used for determining a distortion on a path waveform, inequalities are given as follows;

$$\text{MIN}[p(N)/p(N+1), \; p(N)/p(N-1)] \;>=\; \beta 1$$

5
$$\text{MIN}[p(N+1)/p(N+2), \; p(N-1)/p(N-2)] \;>=\; \beta 2$$

$$\text{MIN}[p(N+2)/p(N+3), \; p(N-2)/p(N-3)] \;>=\; \beta 3$$

Here, MIN[x, y] is a function having a value of the smallest one from the values of x and y. In this case, the smallest one from the values of $p(N+m)/p(N+m+1)$ and $p(N-m)/p(N-m-1)$ is used for detecting a distortion on a path

10 waveform, and it is determined whether the distortion has occurred on the slow slope side of the correlation profile. The comparison threshold values $\beta 1$, $\beta 2$ and $\beta 3$ are respectively provided for each of the ratios of the above

15 inequalities. The comparison threshold values and the ratios between the neighboring correlation values are compared to determine the existence of a distortion on a path waveform.

According to this embodiment, if at least one of the above inequalities is satisfied, it is determined that no

20 distortion has occurred to this path, and this path is recognized as a valid receiving path for demodulation. To the contrary, if none of the above inequalities is satisfied, it is determined that a distortion has occurred to this path.

Fig. 11 is a flowchart showing process steps for an

25 embodiment of a method for recognizing a valid receiving path according to the present invention. At step S10, the path recognizing process starts. At step S12, correlation values between a set of received signals and a plurality of phase-shifted spread codes are acquired at a predetermined sampling

30 rate. At step S14, the correlation values are stored into the

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memory. At step S16, the correlation values are compared with a predetermined noise threshold value. If a correlation value is smaller than the noise threshold value, at step S20 the set of signals having that correlation value at that delay

5   time is recognized as noise. If the correlation values are larger than the noise threshold value, at step S18 a peak value of a correlation profile comprising a plurality of correlation values is compared with the path recognition threshold value.

10   If the peak correlation value is larger than the path recognition threshold value, at step S30 it is determined whether a waveform distortion has occurred based on the correlation profile. According to the determination of the step S30, at step S32 it is determined whether the receiving

15 path represented as the path waveform has any distortion. If it is determined that the receiving path has no distortion, at step S22 the receiving path is recognized as a valid receiving path for demodulating received signals, and the signal level and timing of the receiving path are stored in

20 the memory. If, however, it is determined that the receiving path has a distortion, at step S34 it is further determined whether the existence of distortion is continued from the last cycle of performing the path recognizing process of this embodiment. If it is determined that the existence of

25 distortion is continued from the last cycle performing the path recognizing process, in other words, that the receiving path is determined to have a distortion at both the last and present cycles, at step S20 the receiving path is recognized as a path having noise. If, however, it is determined that

30 the receiving path has a distortion at the present cycle, but did not have any distortion at the last cycle, in other words, that the existence of distortion is not continued, at step S36 the receiving path is recognized as a distorted receiving

path having high signal levels. This path may be used as, for
example, a candidate for valid receiving paths when the
mobile station is in the waiting mode. Further, it may be
possible to use this path for reevaluation for recognition as
5   a valid receiving path by determining the received signal
levels and distortions at the next cycle of performing this
process.

At the step S18, if the peak correlation value is
smaller than the path recognition threshold value, at step
10   S38 it is further determined whether a waveform distortion
has occurred based on the correlation profile. According to
the determination of the step S38, at step S40 it is further
determined whether the receiving path represented as the path
waveform has any distortion. If it is determined that the
15   receiving path has a distortion, at step S20 the receiving
path is recognized as a path having noise. If, however, it is
determined that the receiving path has no distortion, at step
S42 it is further determined whether the absence of
distortion is continued from the last cycle of performing
20   this process. If it is determined that the absence of
distortion is continued from the last cycle, in other words,
that the receiving path is determined to have no distortion
at both the last and present cycles, the receiving path is
recognized as a valid receiving path for demodulating
25   received signals, and the signal level and timing of the
receiving path are stored in the memory at the step S22, If,
however, it is determined that the receiving path has no
distortion at the present cycle but had a distortion at the
last cycle, in other words, that the absence of distortion is
30   not continued, at step S44 the receiving path is recognized
as an undistorted receiving path having low signal levels.
Later, this path may be recognized as a valid receiving path
by determining the received signal levels and the waveform

distortions at the next cycle of performing this process. At step S24, the path recognizing process ends.

Fig. 12 is a flowchart showing an embodiment of a distortion determination process according to the present invention. The distortion determination process starts at step S50. At step S52, a correlation value is multiplied by a comparison threshold value. According to the present embodiment, in order to detect a distortion on a path waveform by using a correlation profile, a peak correlation value $p(N)$ and additional four correlation values, other than the peak correlation value $p(N)$, are used. The first comparison threshold value $\alpha1$ is 0.20 dB for the ratios of $p(N)$ to $p(N+1)$ and $p(N-1)$. The second comparison threshold value $\alpha2$ is 1.95 dB for the ratios of $p(N)$ to $p(N+2)$ and $p(N-2)$. The results of multiplications are as follows;

$$p'(N+1) = p(N+1) \times 0.20 \text{ dB}$$
$$p'(N-1) = p(N-1) \times 0.20 \text{ dB}$$
$$p'(N+2) = p(N+2) \times 1.95 \text{ dB}$$
$$p'(N-2) = p(N-2) \times 1.95 \text{ dB}$$

At step S54, $P(1)$ represents the largest one from the values of $p'(N+1)$ and $p'(N-1)$, and $P(2)$ represents the largest one from the values of $p'(N+2)$ and $p'(N-2)$. At step S56, P_a represents the smallest one from the values of $P(1)$ and $P(2)$.

At step S58, the peak correlation value $p(N)$ is compared with P_a. If P_a is smaller than $p(N)$, at step S62 it is determined that the path has a distortion on the path waveform. If P_a is equal to or larger than $p(N)$, at step S62 it is determined that the path has no distortion. The distortion determination process ends at step S64.

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Fig. 13 is a graph showing a simulation result of a path evaluation performed on paths of consecutive 16 time slots. In this simulation, in order to detect a distortion on a path waveform of a correlation profile, the distortion

5   determination process described above with reference to Fig. 12 is used. In the graph of Fig. 13, a bar represents a level of a peak correlation value of a path. As shown, the levels or peak correlation values of the paths at time slots 0, 5, 6, 8, 9, 10 and 14 are smaller than the peak recognition

10   threshold values. Therefore, according to the conventional path recognizing method, the paths at those time slots are treated as noise and eventually lost.

According to an embodiment of the present invention, even when a peak correlation value of a path is smaller than

15   the path recognition threshold value, the path can be recognized as a valid receiving path for demodulation by detecting a distortion on a path waveform of a correlation profile based on the ratios of peak correlation value to other correlation values. In the simulation result shown in

20   Fig. 13, the paths at the time slots 0, 5, 6, 8, 9, 10 and 14 are recognized as valid receiving paths for demodulation. Therefore, a very stable communication is achieved by recognizing all the paths on consecutive 16 time slots as valid receiving paths.

25   Therefore, according to the present invention, a stable and excellent path recognition method is achieved in a CDMA telecommunication system.

In describing the invention, reference has been made to preferred embodiments and illustrative advantages of the

30   invention., Those skilled in the art, however, and familiar with the instant disclosure of the subject invention may

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recognize various modifications, additions, deletions, substitutions, and other changes that fall within the purview of the subject invention.